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A COMPATIBILITY ASSESSMENT OF THE PROTECTIVE INTEGRATED HOOD MASK WITH ANVIS NIGHT VISION GOGGLES (U)

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AAMRL-TR-90-030

This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

The voluntary informed consent of the subjects used in this research was obtained as required by Air Force Regulation 169-3.

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FOR THE COMMANDER

CHARLES BATES, JR.
Director, Human Engineering Division
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13. ABSTRACT *(Maximum 200 words)* Potential compatibility problems found with the Protective Integrated Hood Mask (PIHM) and the Aviator's Night Vision Imaging System (ANVIS) were evaluated. The PIHM is worn under a standard HGU-55/P helmet and is designed to protect USAF aircrew members in a chemical environment. Visual acuity through ANVIS/PIHM, ANVIS horizontal and vertical intensified fields of view while wearing PIHM, and distortion and transmissivity of the PIHM visor were determined. Acuity through ANVIS with and without PIHM was assessed under quarter moon and starlight illumination. Acuity was tested using 20% and 90% contrast Landolt C targets depicted in one of four orientations. ANVIS/PIHM viewing resulted in acuity reductions of approximately 6% for both contrast levels at quarter moon illumination. No acuity loss was present at starlight illumination. Tests of horizontal and vertical ANVIS intensified fields of view resulted in no significant losses when PIHM was donned. Distortion and transmissivity data for the PIHM visor were compared to a clear AF visor, and it was found that the PIHM visor did not deviate significantly from the clear AF visor. Overall conclusions were that potential compatibility problems of ANVIS and PIHM integration can be reduced or eliminated with proper fit and adjustment of the ANVIS/PIHM.

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Summary

A laboratory evaluation was conducted on the Protective Integrated Hood Mask (PIHM) to determine its compatibility with the Aviator's Night Vision Imaging System (ANVIS). PIHM will be used by tanker, transport, and bomber aircrews for protection in a chemical environment. ANVIS is a night vision goggle currently used by these same aircrews to aid in visual performance during night missions.

Parameters which were evaluated included: visual acuity, intensified field of view, distortion of PIHM visor, and transmissivity of PIHM visor. For the tests of visual acuity and intensified field of view, the approach was to evaluate visual performance through ANVIS alone, and compare it to performance with PIHM/ANVIS. Distortion and transmissivity of the PIHM visor were evaluated by comparing the measurement data to a standard Air Force clear visor.

The results for the visual acuity and intensified field of view tests indicated no significant reduction in visual performance when the PIHM was donned. Likewise, data obtained from distortion and transmissivity tests showed no significant differences from the standard clear visor.

As a result of this evaluation, it became evident that proper training procedures for donning the PIHM with ANVIS need to be developed and adopted. Optimal visual performance was primarily achieved because the subjects who participated in the evaluation had assistance in donning the equipment from a life support specialist. This specialist ensured exact fit of the PIHM and proper alignment of ANVIS. It is possible that reductions in visual performance will occur if proper PIHM/ANVIS fit is not achieved.

Preface

This evaluation was completed under work unit 7184-18-07 by members of the Crew Systems Effectiveness Branch, Human Engineering Division, Armstrong Aerospace Medical Research Laboratory, Wright Patterson Air Force Base, Ohio and Logicon Technical Services, Inc., Dayton, Ohio. Funding was provided by the Life Support Systems Programs Office (HSD/YAGD).

The authors express appreciation to the following individuals for their assistance on this project: Dr Lee Task, AAMRL/HEF, TSgt Laurie DeCamp, 3246TW/TZFC, Eglin AFB, FL; and David Sivert and Annette Zobel, Logicon Technical Services, Inc. We also wish to thank Bob Sanctis, Modern Technologies, Inc., and Capt Delapena, HSD/YAGD, for their cooperation in obtaining the PIHMs for the evaluation.

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Introduction

The Aircrew Eye Respiratory Protection System (AERPS) is designed to protect USAF aircrew members in a potential or known chemical environment without imposing physiological burdens or degrading mission capability. The Protective Integrated Hood Mask (PIHM) is the candidate subsystem of AERPS for use by aircrew members of tanker, transport, and bomber aircraft. The PIHM is designed to be worn under a standard HGU-55/P flight helmet.

Prior to C-130E flight testing, the Life Support Special Program Office, HSD/YAG, requested AAMRL/HEF to evaluate potential compatibility constraints that may result from wearing the Aviator's Night Vision Imaging System (ANVIS) with the PIHM. While wearing the PIHM, ANVIS is mounted to the helmet using a special bracket that allow the night vision goggles (NVGs) to be positioned just in front of the PIHM visor. The mounting bracket used was designed by the Special Mission Operational Test and Evaluation Center (SMOTEC) for pilots of special operations aircraft. Integration of the PIHM with ANVIS results in the PIHM visor being located between the users eye and the ANVIS objective lens.

Since there are normally no obstructions between the user's eye and the ANVIS objective lens, the integration of the PIHM with the ANVIS could limit aircrew visual capabilities during NVG missions. The specific concerns raised by HSD/YAG included: reductions in the ANVIS intensified field of view (FOV), loss of visual acuity, cockpit lighting interference produced by glare from the visor, anthropometric fit of the PIHM/ANVIS combination and the distortion and transmissivity of the PIHM visor.

The AAMRL Night Vision Operations (NVO) laboratory, in support of the AERPS evaluation, conducted both on-site and laboratory testing to assess these compatibility issues. The on-site evaluation was completed at Pope AFB NC using qualified C-130E pilots to examine the PIHM/ANVIS intensified FOV, cockpit lighting compatibility, and a limited anthropometric evaluation. The on-site evaluation demonstrated no significant

compatibility problems with the PIHM/ANVIS combination in any of the areas examined. The complete results of the on-site evaluation are described in a separate AAMRL technical report [1].

The purpose of the laboratory evaluation described in this report was to assess the visual acuity through the PIHM/ANVIS combination and provide intensified FOV measurements for a wider range of PIHM sizes. In addition, distortion and transmissivity of the PIHM visor were measured. This report describes the results obtained in the AAMRL NVO laboratory evaluation and in conjunction with the AAMRL field study cited above, provides recommendations for optimal performance of the PIHM/ANVIS integrated system.

Method

2.1 Visual Acuity

Subjects

Visual acuity through the ANVIS, both with and without the PIHM, was measured for five males and one female ranging in age from 21 to 45 years. All subjects had Snellen visual acuity of at least 20/20, corrected or uncorrected.

Apparatus and Stimuli

Each subject was individually tested in the AAMRL zoom lane facility. The zoom lane consists of a computer controlled, motorized cart on a 40 foot track. Landolt C acuity charts having modulation contrasts of 20% and 90% were used. The acuity charts consisted of three to five Cs having one of four orientations (right, left, up, and down) and mounted on a white foam core background. The subject's view of the acuity charts is displayed in Figure 2.1. A moonlight simulator which approximated quarter moon and starlight illumination levels was used to illuminate the chart. The simulator was mounted on a tripod which was adjusted to provide calibrated illumination on the surface of the acuity charts.

Acuity target sizes (in Snellen notation) ranged from 20/32 to 20/71 in increments of $\sqrt[4]{2}$ for the quarter moon illumination level, and 20/80 to 20/300 (also in increments of $\sqrt[4]{2}$) for the starlight illumination level. The results of a pilot study conducted prior to the evaluation were used to determine the acuity size ranges for each illumination and contrast level. A pair of ANVIS third generation NVGs were mounted with velcro strips to a HGU-55/P helmet using the same mounting bracket used at Pope AFB. Medium and large helmets were used for the subjects tested.

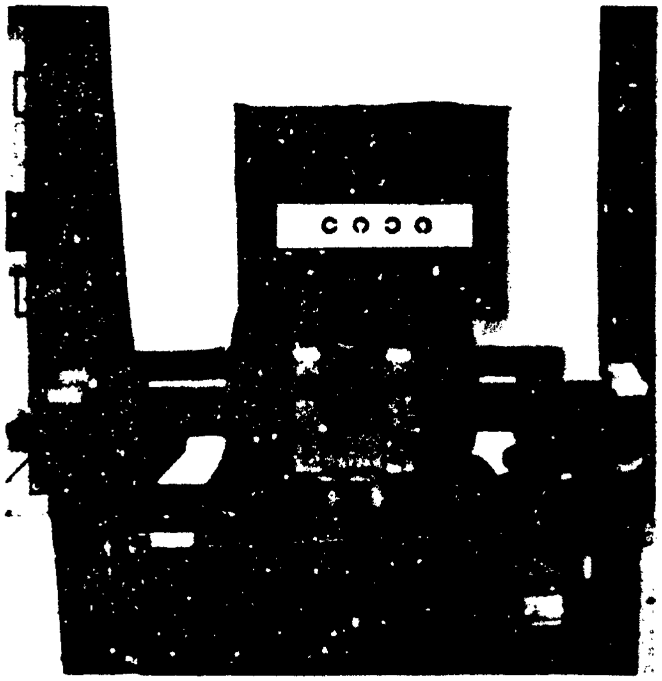

Figure 2.1: Subject's View of Landolt C Acuity Chart

Procedure

Each subject was seated in the motorized cart so that the distance from the NVG objective lens to the acuity chart was 30 feet. The cart was moved to a distance of 12 feet for the low contrast condition at the starlight illumination level. The cart was stationary during each test sequence. Visual acuity was measured for each subject while wearing the ANVIS without the PIHM first (baseline). The subject then donned the PIHM/ANVIS combination and repeated the procedure under a new chart presentation order.

Each subject viewed 23 charts for both the baseline and PIHM conditions. Subjects were required to determine the orientation of the Cs contained on each chart in succession, reading from left to right. If the experimenter was unable to hear any response, the subject was asked to read the entire chart again. Acuity measurements were obtained for 20 and 90 percent contrast targets at both quarter moon (.00589 ft-L.) and starlight (.00024 ft-L.) illumination levels.

2.2 Intensified Field of View (FOV) Measurements

Subjects

Horizontal and vertical intensified FOVs were measured for seven males and one female ranging in age from 21 to 45 years. Four subjects were USAF personnel from the WPAFB

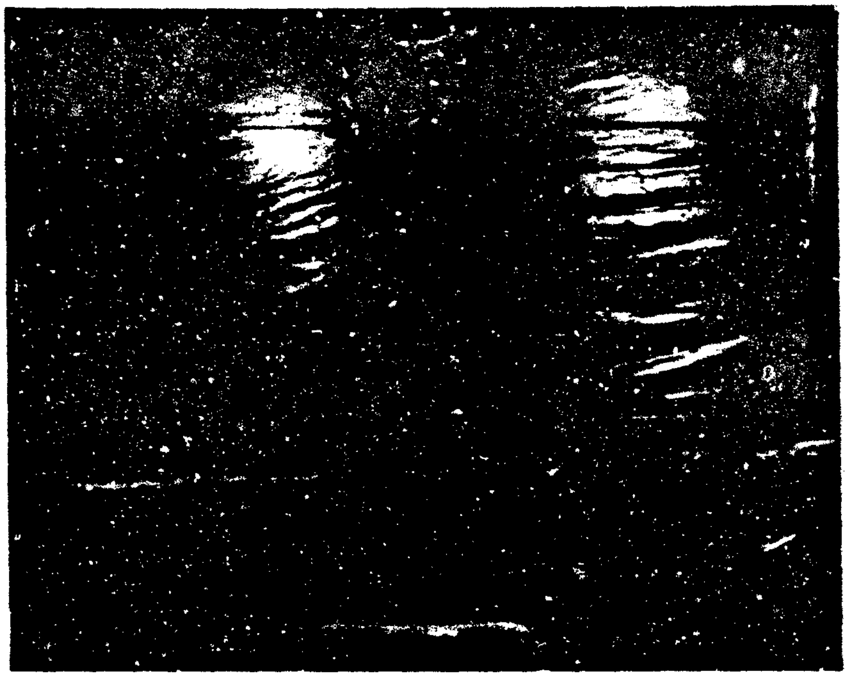

Figure 2.2: Visual Field Used to Measure PIHM/ANVIS Horizontal and Vertical Intensified FOV

Physiological Medical Training Division who were tested with their own custom fit HGU-55/P helmet. The remaining subjects wore HGU-55/P helmets without custom fit liners. All subjects received assistance in donning the PIHM and adjusting the ANVIS from the same life support specialist who supported the on-site evaluation and the two experimenters.

Procedure

Intensified FOVs were measured for each subject using a 5 foot square field marked off on a white projection screen (see Figure 2.2). A small light emitting diode (LED) was positioned in the center of the field to serve as a fixation point. Subjects were seated so that the ANVIS objective lens was at a distance of 6 feet from the center of the visual field. A second LED was moved across the horizontal and vertical scale by the experimenter. The subject called out when the LED was "just visible" at the edge of the intensified NVG image. Two measurements were recorded for each viewing condition. Both the right and left monocular FOVs were measured as well as the FOV for binocular viewing. Baseline FOV measurements (HGU-55/P + ANVIS) were recorded for each subject prior to donning the PIHM. This was done to ensure that each subject was able to attain a full 40 degree intensified field of view based upon helmet fit. After a 40 degree field was obtained, the subject donned the PIHM/ANVIS combination and the FOV measurement was repeated.

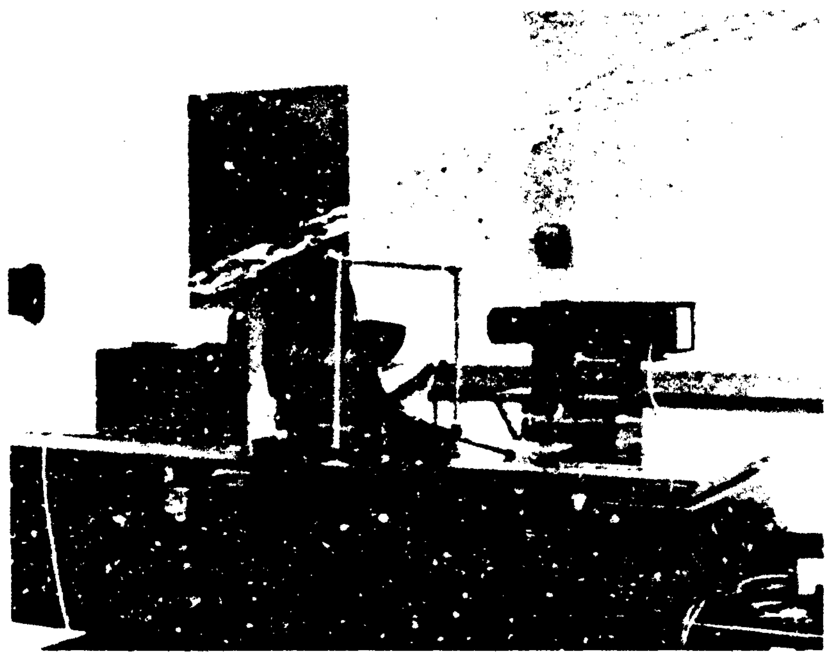

Figure 2.3: Apparatus Used for Measuring Angular Deviation Through PIHM Visors

2.3 Distortion and Transmissivity of PIHM Visor

Distortion

The angular deviation of three PIHM visors was measured using a UDT two axis detector and a helium neon (HeNe) laser, (see Fig 2.3). The amount of error in milliradians was recorded from -15°to +15°in azimuth (in 5°increments) at elevations of +/- 10, 20, 30, 40 and 0 degrees. The error recorded from the left eye was subtracted from the error recorded for the right eye to determine the angular deviation between the two eyes at each position. The eye convergence and divergence data (+ and - horizontal deviation) were then plotted as a function of elevation for each mask. Likewise, plots were made of dipvergence (deviation in vertical axis) in milliradians as a function of azimuth angle for the elevations listed above. These plots are included in Appendix 5.1. Distortion was further assessed by taking photographs through each visor of a large grid board positioned ten feet in front of the camera. These photographs were examined for distortion.

Transmissivity

Transmissivity is the ratio of the light exiting a transparent material to the light that was incident on it. Photopic transmissivity is dependent upon the spectral transmissivity of the PIHM visor, the CIE 1931 photopic response of the human visual system, and

the spectral distribution of the object viewed. A neutral material will have the same transmission characteristics regardless of the object viewed. The spectral transmission of three PIHM visors was measured for wavelengths of 380-760 nm using a Photo Research 1980B spectral scanning radiometer. In addition, the spectral transmission of several objects (both natural and man-made) was measured. Using the equation below, the photopic transmissivities of these objects were calculated. The results of these calculations were compared to a standard AF clear visor (which is a fairly neutral material) to determine if visibility through the PIHM visor was significantly different.

$$T = \frac{\int_{380}^{760} T_\lambda \times S_\lambda \times V_\lambda d\lambda}{\int_{380}^{760} S_\lambda \times V_\lambda d\lambda}$$

where: T = photopic transmissivity

T_λ = spectral transmissivity of the visor

V_λ = CIE 1931 photopic sensitivity curve

S_λ = spectral distribution of the object viewed

Results

3.1 Visual Acuity

Visual acuity measurements obtained for ANVIS and the PIHM/ANVIS viewing conditions are listed in Table 3.1 for quarter moon illumination and in Table 3.2 for starlight illumination, respectively. The values in Tables 3.1 and 3.2 represent the Snellen fraction (20/value) for which at least 75% accuracy was achieved. The percent change in visual acuity calculated from the Snellen decimal resulting from ANVIS/PIHM viewing is listed in Table 3.3 for each subject as a function of illumination level and acuity target contrast.

The results showed that slight reductions in visual acuity occurred only at the quarter moon illumination level, averaging across subjects. Inspection of Table 3.1 reveals that this reduction is mostly attributable to subject four. All other subjects displayed little or no change from baseline levels. No visual acuity loss was measured at the starlight illumination level, when averaging across subjects. The differences in visual acuity between baseline ANVIS and PIHM/ANVIS were not statistically significant for either illumination level.

3.2 Intensified Field of View

The degrees of visual angle measured to the right and left of the center fixation point were summed to obtain the full horizontal field of view for each viewing condition. The vertical field of view was obtained by adding the degrees of visual angle measured above and below the fixation point. The monocular and binocular intensified fields of view measured for the PIHM/ANVIS combination are listed in Table 3.4.

The average horizontal FOVs for the right, left, and binocular viewing were 36, 36, and 38 degrees, respectively. Thus viewing through the PIHM/ANVIS combination resulted in a 10 percent horizontal FOV loss for each eye indvidually and a 5 percent loss for viewing

Table 3.1: Visual Acuity (20/) for Baseline and PIHM/ANVIS Viewing Conditions at Quarter Moon Illumination for 20% and 90% Contrast Landolt Cs

QUARTER MOON				
	20% CONTRAST		90% CONTRAST	
SUB.	BASE	PIHM	BASE	PIHM
1	20/57	20/57	20/40	20/36
2	71	71	50	57
3	40	40	32	32
4	45	71	36	45
5	40	40	36	36
6	45	40	32	32
AVG	50	53	38	40

Table 3.2: Visual Acuity (20/) for Baseline and PIHM/ANVIS Viewing Conditions at Starlight Illumination for 20% and 90% Contrast Landolt Cs

STARLIGHT				
	20% CONTRAST		90% CONTRAST	
SUB.	BASE	PIHM	BASE	PIHM
1	20/225	20/225	20/100	20/100
2	225	250	100	111
3	225	250	91	100
4	225	225	91	91
5	225	200	80	80
6	250	225	111	80
AVG	229	229	96	94

Table 3.3: Percent (%) Change in Decimal Visual Acuity From Baseline to ANVIS/PIHM Viewing for 20% and 90% Contrast Landolt Cs

	QUARTER MOON		STARLIGHT	
SUB	20%	90%	20%	90%
1	0%	10%	0%	0%
2	0	-14	-11.1	-11.0
3	0	0	-11.1	-9.9
4	- 57.8	-25	0	0
5	0	0	11.1	0
6	11.1	0	10	27.9
AVG.	-7.8	-4.8	.2	1.2

Table 3.4: Horizontal and Vertical Intensified Field of View (in degrees) for PIHM/ANVIS Viewing.

		HORIZONTAL			VERTICAL		
SUB NO.	PIHM SIZE	MONOC. RT.	MONOC. LT.	BINOC. -	MONOC. RT.	MONOC. LT.	BINOC. -
1	SMALL	34°	38°	38°	40°	38°	38°
2	SMALL	39	37	37	38	39	38
3	MED	35	31	34	33	40	39
4	MED	35	38	40	36	35	37
5	LARGE	37	34	40	38	26*	37
6	LARGE	36	37	39	39	40	39
7	LARGE	38	39	38	36	37	36
8	LARGE	32	35	37	32	33	34
AVG.	-	36	36	38	37	36	37

* Proper positioning of the oculars could not be achieved for this subject.

with both eyes. The average vertical fields of view measured for right, left, and both eyes respectively were 37, 36, and 37 degrees, which represented reductions from baseline of 7 to 10 percent.

3.3 Distortion and Transmissivity

Distortion

Differences in angular deviation (in milliradians) between the right and left eye positions were calculated to determine binocular convergence, divergence, and dipvergence as a function of azimuth angle for each visor. Examination of the data obtained for each mask showed that the angular deviation between the two eye postions was within acceptable limits for eye convergence and dipvergence. It should be noted that no divergence occurred for any of the PIHM visors. Plots of eye convergence and dipvergence are shown in Appendix 5.1. In addition, no distortion was observed in the photographs taken of the grid board through each visor.

Transmissivity

The photopic transmissivities which were calculated for several exterior scene objects as seen through the PIHM visors and clear visor are listed respectively in Table 3.4. Examination of the data shows that transmission of the PIHM visors varied from 88-90%. The transmission of the clear visor was 96%. The difference in transmission between the clear visor and PIHM visors can be considered negligible.

Table 3.5: Photopic transmission (%) calculated for three PIHM visors sizes with respect to exterior scene objects

OBJECT	PIHM VISOR SIZE			CLEAR AF VISOR
	SMALL	MEDIUM	LARGE	
Trees on Hill	90.1%	90.2%	88.2%	95.9%
Grass on Hill	90.1	90.3	88.3	95.9
Pavement	90.1	90.3	86.6	95.9
Blue sky	90.1	90.2	88.3	95.9
Horizon haze	90.1	90.2	88.3	95.9
Gravel on rooftop	90.1	94.0	88.3	95.9
Grass field	90.1	90.2	88.3	95.9
Cream building	90.1	90.3	88.3	95.9
Red brick building	90.2	90.3	88.3	95.9
Dark brown roof	90.2	90.3	88.3	95.9

Conclusions and Recommendations

The laboratory evaluation described in this report examined the compatibility of ANVIS NVGs with the PIHM system. Both the data and observations indicated that the integration of ANVIS with the PIHM did not result in any significant compatibility problems. However, the results demonstrated the importance of following proper PIHM donning procedures and careful adjustment of the ANVIS to ensure optimal performance. The conclusions and recommendations drawn from each test objective are described separately in the following paragraphs.

4.1 Visual Acuity

The results of the visual acuity assessment revealed no significant reduction in visual acuity when wearing the ANVIS/PIHM combination. If a proper system fit is achieved, no acuity reductions from normal ANVIS viewing should be expected when wearing the PIHM/ANVIS combination. It is recommended that careful attention is given to refocussing the ANVIS after donning the PIHM to ensure optimal acuity.

4.2 Intensified Field of View

The PIHM/ANVIS combination resulted in small reductions in the horizontal and vertical intensified fields of view. The average reduction from the 40 degree optimal FOV ranged between 2 and 4 degrees for both the on-site and AAMRL lab evaluation. This rather insignificant effect on the intensified FOV was attributable to the careful attention given to proper donning and adjustment of the PIHM/ANVIS combination. Each subject received assistance in donning the PIHM and adjusting the ANVIS mount from life support

specialists prior to testing to ensure that the NVG oculars were centered over each eye and as close to the visor as possible. Without careful adjustment or proper fit, the PIHM/ANVIS combination could potentially reduce intensified field of view significantly. Improper adjustment or alignment of the NVG oculars under normal use could be magnified by the PIHM/ANVIS combination unless assistance is provided when donning the equipment. Therefore, it is recommended that proper training procedures are developed for donning the PIHM/ANVIS.

Training procedures developed for PIHM/ANVIS missions should emphasize PIHM system fit as well as proper ANVIS adjustment. The mounting bracket should allow the NVG oculars to be positioned directly in front of the eyes and level with the line of sight. The vertical adjustment range of the mounting bracket may have to be increased to ensure proper positioning. The NVGs should also be positioned as close to the visor as possible without damaging the visor. Optimal field of view will be achieved with the oculars just touching the visor. Mole skin padding could be placed around the eyepiece (inner) lens to eliminate the risk of scratching the PIHM visor.

4.3 Distortion and Transmissivity

The data obtained for the angular deviation measurements and visor distortion evaluation were within acceptable limits for PIHM/ANVIS use. The transmissivity calculations resulted in values similar to those obtained for the clear visor which has already been adopted by the Air Force for flight use.

Bibliography

[1] Riegler, Joseph T., Donohue-Perry, Mary M., Hausmann, Martha A. "A Field Evaluation of the Compatibility of the Protective Integrated Hood Mask with ANVIS Night Vision Goggles (U)", Armstrong Aerospace Medical Research Laboratory, June 1990.

Appendix

5.1 Eye Convergence and Dipvergence for PIHM Visors

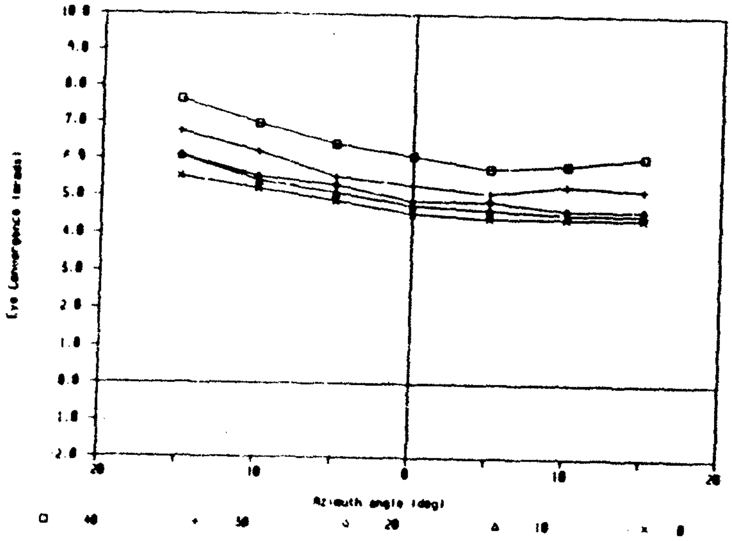

Figure 5.1: Small PIHM Visor Convergence as a Function of Azimuth for Negative Elevation Angles

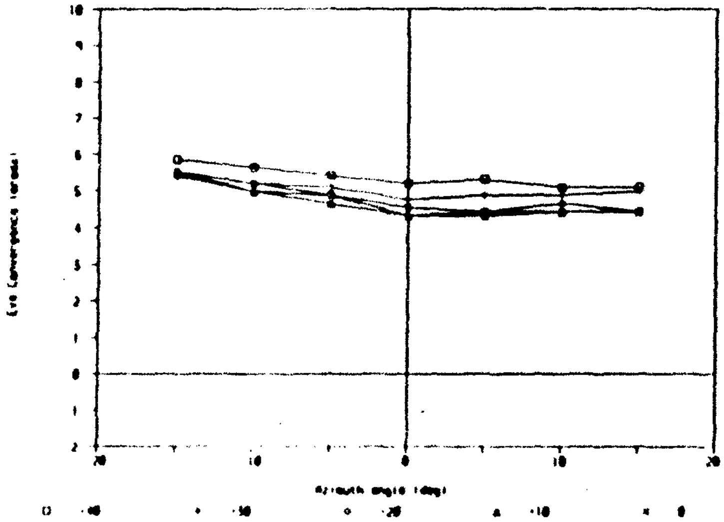

Figure 5.2: Small PIHM Visor Convergence as a Function of Azimuth for Positive Elevation Angles

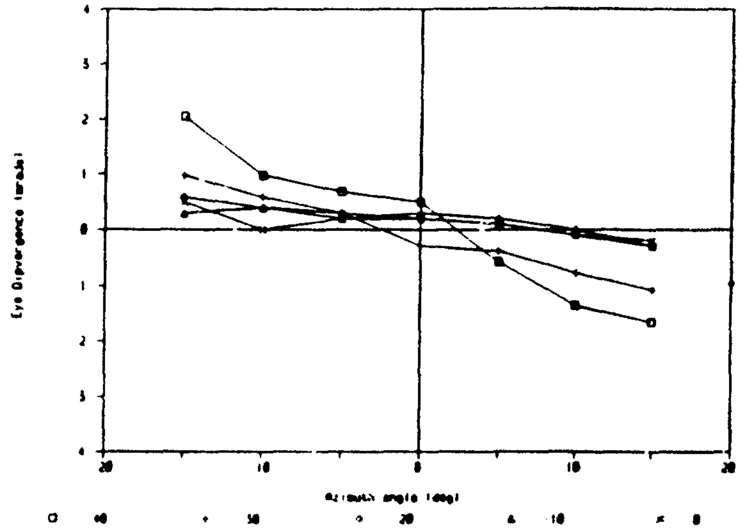

Figure 5.3: Small PIHM Visor Dipvergence as a Function of Azimuth for Negative Elevation Angles

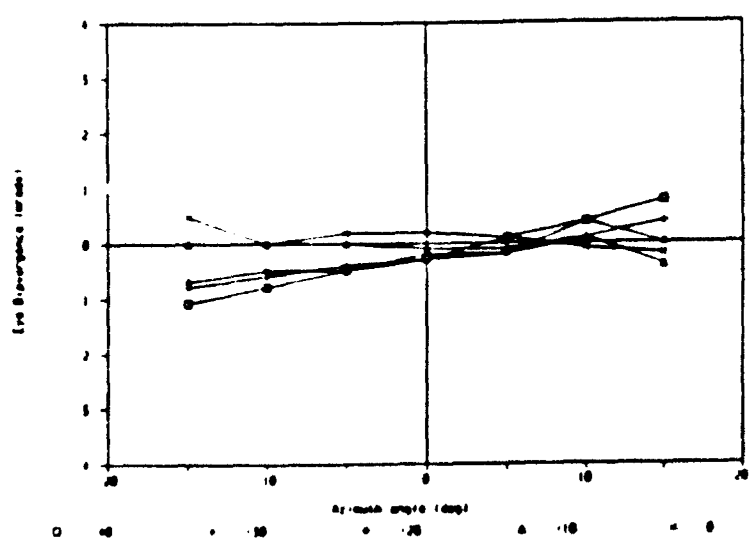

Figure 5.4: Small PIHM Visor Dipvergence as a Function of Azimuth for Positive Elevation Angles

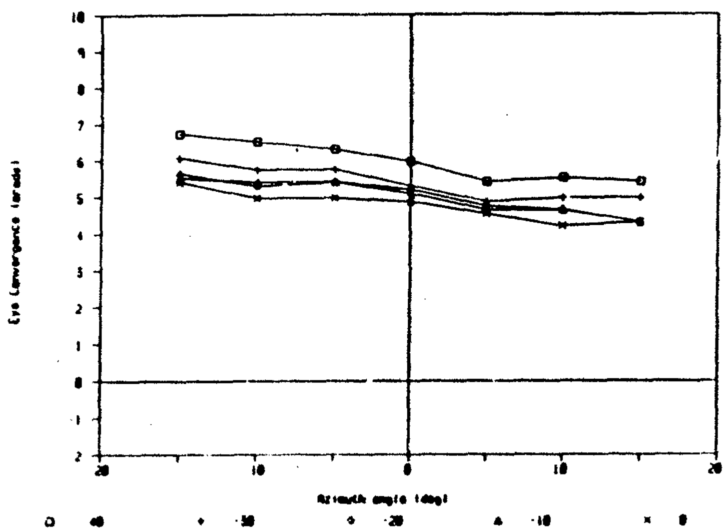

Figure 5.5: Medium PIHM Visor Convergence as a Function of Azimuth for Negative Elevation Angles

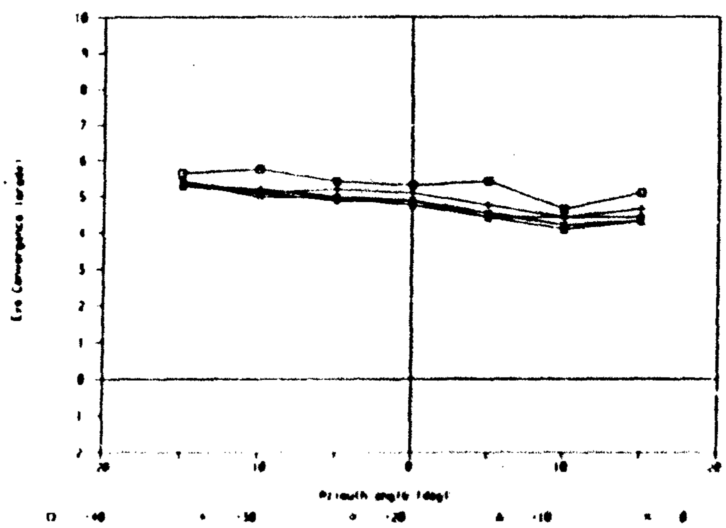

Figure 5.6: Medium PIHM Visor Convergence as a Function of Azimuth for Positive Elevation Angles

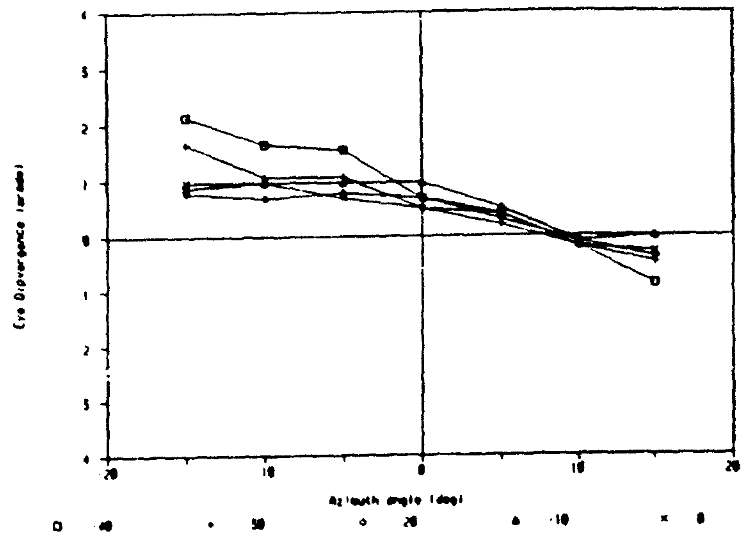

Figure 5.7: Medium PIHM Visor Dipvergence as a Function of Azimuth for Negative Elevation Angles

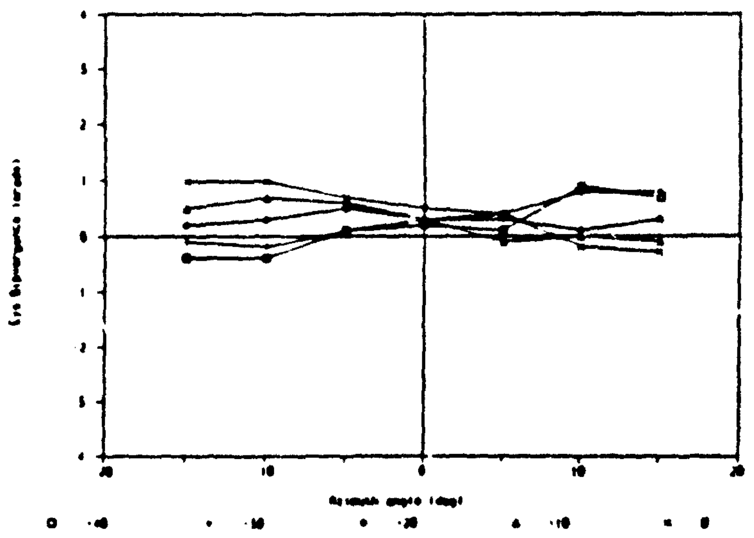

Figure 5.8: Medium PIHM Visor Dipvergence as a Function of Azimuth for Positive Elevation Angles

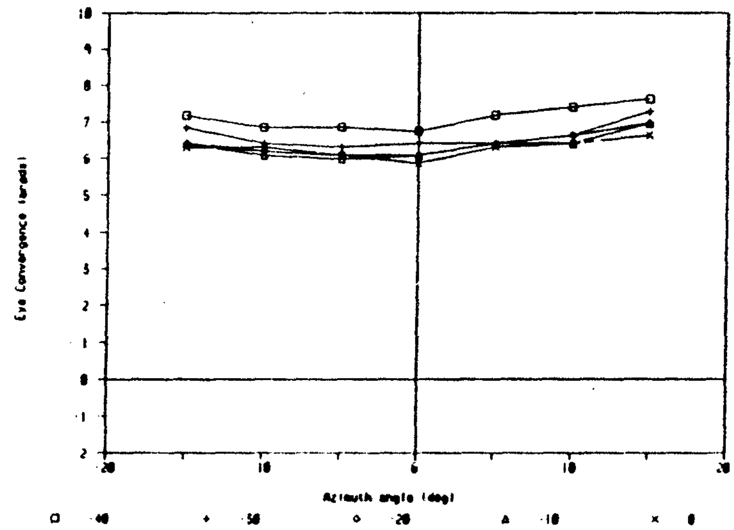

Figure 5.9: Large PIHM Visor Convergence as a Function of Azimuth for Negative Elevation Angles

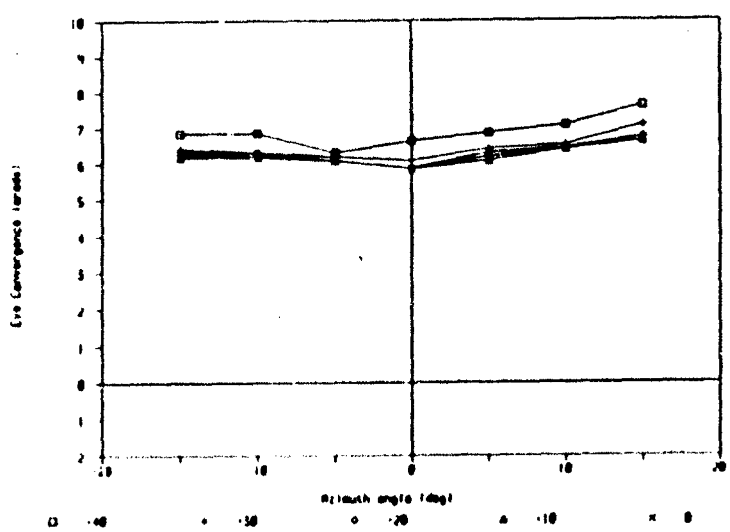

Figure 5.10: Large PIHM Visor Convergence as a Function of Azimuth for Positive Elevation Angles

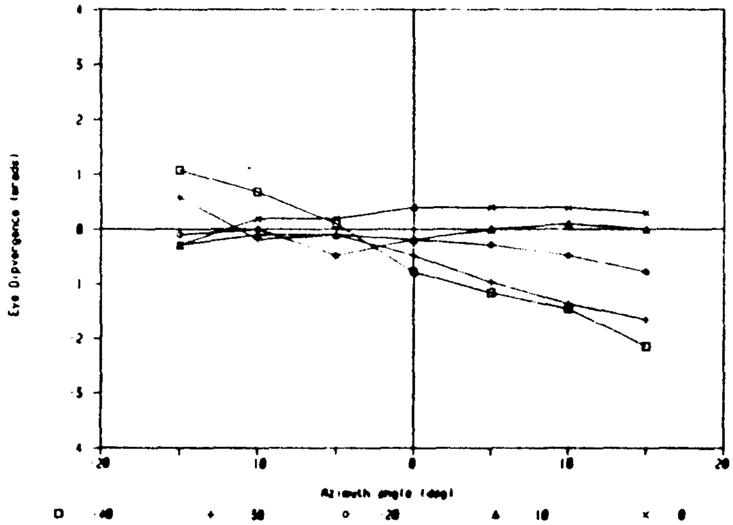

Figure 5.11: Large PIHM Visor Dipvergence as a Function of Azimuth for Negative Elevation Angles

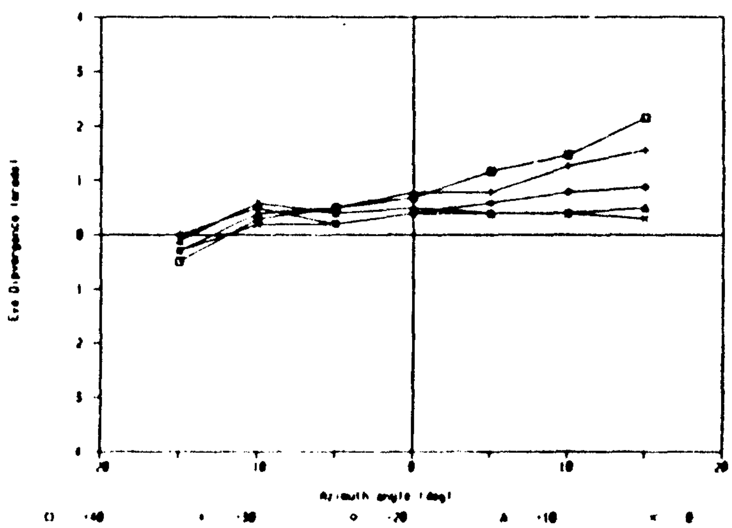

Figure 5.12: Large PIHM Visor Dipvergence as a Function of Azimuth for Positive Elevation Angles

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